

CLAIMS:

1. A digital image coding apparatus, for generating a representation of spatially filtered images that are obtainable from a common source image by application of spatial filter operations with respective filter bandwidths, wherein a dependence of image information in the filtered images on position in the filtered image and filter bandwidth is represented by information that defines a surface in a space that has at least the position in the filtered image and the filter bandwidth as coordinates, the shape and position of the surface at least partly defining said dependence, the apparatus comprising:
- an input for receiving an image signal that represents the source image as a function of position in the image domain;
 - 10 - a computation unit,
- characterized in that the true version of the surface that follows from the source image is approximated by an approximate version of the surface that is represented by a set of control points, the computation unit being arranged to select coordinate values of the set of control points, including selection of filter bandwidth components of the coordinate values, dependent on the image signal, so that the a quality of approximation is optimized.
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2. A digital image coding apparatus according to Claim 1, wherein at least one of the control points is selected so that its coordinates satisfies a predetermined equation or set of equations with parameters that depend on the source image through its effect on the filtered images, the coordinates being determined by solving the equation or set of equations, by iterative evaluation of the equations or set of equations for a series of points in said space that converges to at least one of the control points.
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3. A digital image coding apparatus according to Claim 2, wherein the surface expresses a shape and location of a boundary between regions in the filtered images as a function of filter bandwidth of the filtered images, wherein respective ones of the regions are selected on the basis of a positive sign of a determinant of a curvature matrix in these regions.
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4. A digital image coding apparatus according to Claim 3, wherein the control points are located by computing locations of points where the image information assumes extreme values in the regions.

5 5. A digital image coding apparatus according to Claim 4, wherein the control points are located by computing values of filter bandwidths of meeting points of respective lines of points for respective regions and/or originating points of such lines, each line forming a collection of particular image locations for respective filter bandwidth values for a respective region, at which particular image location the image information assumes an
10 extreme value as a function of image location when filtered with that respective bandwidth.

6. A digital image coding apparatus according to Claim 1, wherein the surface expresses a shape and location of a boundary between regions in the filtered images as a function of filter bandwidth of the filtered images, wherein respective ones of the regions are
15 selected on the basis of values of an image property inside the region, the value of the image property changing between adjacent regions.

7. A digital image coding apparatus according to Claim 6, wherein the image property is a sign of a curvature of the image information as a function of image position.
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8. A digital image coding apparatus according to Claim 7, wherein the generated representation of filtered images includes information representing a second order derivative of the image information in the regions as a function of position, the information representing a second order derivative being provided per surface in common for a plurality of filter
25 bandwidth values.

9. A digital image coding apparatus according to Claim 6, wherein at least part of the control points are selected to coincide substantially with branch points of a skeleton of the true version of the surface.
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10. A digital image coding apparatus according to Claim 7, wherein the generated representation of filtered images includes information representing a second order derivative of the image information in the regions as a function of position, the information representing

a second order derivative being provided per branch in the skeleton between pairs of branch points, common for filter bandwidth values along the branch.

11. A digital image coding apparatus according to Claim 1, wherein selection of
5 the control point comprises selecting topologically characteristic points of the true version of the surface as control points.

12. A digital image coding apparatus according to Claim 1, wherein selection of
the control points comprises selecting to add a proposed control point for a region of the
10 source image, followed by searching for a position to place the proposed control point in said space, including searching for the filter scale component of the coordinates of the proposed control point.

13. A digital image coding apparatus according to Claim 1, wherein a geometric
15 shape that determines the approximate version of the surface is represented substantially by interpolation between control points, selection of at least one control point comprising searching for a position of the at least one control point, so that the position substantially maximizes maximum distances at which additional control points can be located, so that the interpolation from said at least one control point on mutually opposite sides of the at least one
20 control point in said space to the additional control points approximates the geometric shape for the true surface with a required accuracy by interpolation on both mutually opposite sides.

14. A digital image coding apparatus according to Claim 1, wherein said space in
addition has an image information value as coordinate, the image position, filter bandwidth
25 and image information coordinates of a point on the surface representing that a pixel location in a filtered image with the filter bandwidth coordinate of the point, with the image position coordinates of the point, has the image information coordinate of the point as image information value.

30 15. A digital image coding apparatus according to Claim 1, wherein the control points are selected substantially at points of maximum curvature of the true version of the surface.

16. A digital image coding apparatus according to Claim 1, wherein the control points are selected substantially to minimize a number of control points that is needed to reduce an approximation error, between the approximate version of the surface and the true version of the surface, to at most a predetermined error.

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17. A digital image coding apparatus according to Claim 1, wherein the coordinates of the control points are selected substantially to minimize an approximation error between the approximate version of the surface and the true version of the surface, when at most a predetermined number of control points is used to define the approximation surface.

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18. A digital image coding apparatus according to Claim 1, wherein the digital image representation represents a time-series of images as a function of time, wherein the coordinates of said space include a time coordinate, time components of the coordinates of the control points being selected dependent on the image signal, so that the selection optimizes a quality of approximation by an approximate version of the surface of a true version of the surface that follows from the source image.

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19. A digital image coding apparatus according to Claim 18, wherein the digital image representation represents temporally filtered images as a function of time and temporal filter bandwidth, wherein the coordinates of said space include a temporal filter bandwidth coordinate, temporal filter bandwidth components of the coordinates of the control points being selected dependent on the image signal, so that the selection optimizes a quality of approximation by an approximate version of the surface of a true version of the surface that follows from the source image.

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20. A digital image generating apparatus for generating a display image from a digital image representation that represents spatially filtered images that are obtainable from a common source image by application of spatial filter operations with respective filter bandwidths, wherein a dependence of image information in the filtered images on position in the filtered image and filter bandwidth is represented by information that defines a surface in a space that has at least the position in the filtered image and the filter bandwidth as coordinates, the shape and position of the surface at least partly defining said dependence, the apparatus comprising:

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- an input for receiving a selected filter bandwidth value and a specification of a matrix of locations in said space with said filter bandwidth value as filter bandwidth coordinate value, each location in said matrix being defined for a respective pixel location in the display image;
- 5 - an image value computation circuit arranged to compute pixel values of the display image using the relative position of the locations in the matrix with respect to the control points, relative differences between the selected filter bandwidth value and filter bandwidth coordinates of the control points being computed individually for each control point that is used.
- 10 21. A digital image generating apparatus according to Claim 19, the apparatus comprising :
- an input for receiving a specification of a transformation from a group that includes rotations, scalings and/or translations and/or combinations thereof;
- 15 - the image value computation unit being arranged to apply a transformation of the control points relative to coordinates of the locations of the matrix, prior to computation of the pixel values using the relative position of the locations of the matrix with respect to the control points.
- 20 22. A digital image generating apparatus according to Claim 19, wherein the digital image representation represents a time-series of images as a function of time, wherein the coordinates of said space include a time coordinate, the control points having independently selectable time coordinate values:
- the input being received to receive a selected time value;
- 25 - the image value computation circuit being arranged to compute pixel values of the display image using the relative position of the locations in the matrix with respect to the control points, relative differences between the selected time value and time coordinate components of the control points being computed individually for each control point that is used.
- 30 23. A digital image coding apparatus according to Claim 1, wherein the digital image representation represents temporally filtered images as a function of time and temporal filter bandwidth, wherein the coordinates of said space include a temporal filter bandwidth

coordinate, the control points having independently selectable temporal filter bandwidth coordinate values:

- the input being arranged to receive a selected temporal filter bandwidth value;
- the image value computation circuit being arranged to compute pixel values of

5 the display image using the relative position of the locations in the matrix with respect to the control points, relative differences between the temporal filter bandwidth value and temporal filter bandwidth coordinate components of the control points being computed individually for each control point that is used.

10 24. A digital image coding method, for representing spatially filtered images that are obtainable from a common source image by application of spatial filter operations with respective filter bandwidths, wherein a dependence of image information in the filtered images on position in the filtered image and filter bandwidth is represented by information that defines a surface in a space that has at least the position in the filtered image and the
15 filter bandwidth as coordinates, the shape and position of the surface at least partly defining said dependence,

characterized in that the method comprises:

- approximating a true version of the surface, which follows from the source image, by an approximate version of the surface, whose position and shape is described by
20 locations of a set of control points in said space;
- selecting coordinate values of the control points, including filter bandwidth components of the coordinate values, dependent on the content of the common source image, so as to optimize a quality of approximation of the true version of the surface by the approximate version of the surface.

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25. A digital image coding method according to Claim 1, wherein the digital image representation represents a time-series of images as a function of time, wherein the coordinates of said space include a time coordinate, time components of the coordinates of the control points being selected dependent on the image signal, so that the selection
30 optimizes a quality of approximation by an approximate version of the surface of a true version of the surface that follows from the source image.

26. A computer readable medium comprising a program of machine instructions to make a programmable computer perform the method of Claim 23.

27. A method of generating a display image from a digital image representation that represents spatially filtered images that are obtainable from a common source image by application of spatial filter operations with respective filter bandwidths, wherein a

5 dependence of image information in the filtered images on position in the filtered image and filter bandwidth is represented by information that defines a surface in a space that has at least the position in the filtered image and the filter bandwidth as coordinates, the shape and position of the surface at least partly defining said dependence, the method comprising:

- defining a selected filter bandwidth value and a matrix of locations in said
- 10 space with said filter bandwidth value as filter bandwidth coordinate value, each location in said matrix being defined for a respective pixel location in the display image;
- computing pixel values of the display image using the relative position of the locations in the matrix with respect to a set of control points describing an approximation of the true version of the surface, relative differences between the selected filter bandwidth
- 15 value and filter bandwidth coordinates of the control points being computed individually for each control point that is used.

28. A method of generating a display image according to Claim 27, the method comprising:

- 20 - specifying a transformation from a group that includes rotations, scalings and/or translations and/or combinations thereof;
- applying a transformation of the control points relative to coordinates of the locations of the matrix, prior to computation of the pixel values using the relative position of the locations of the matrix with respect to the control points.

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29. A method of generating a display image according to Claim 27, wherein the digital image representation represents a time-series of images as a function of time, wherein the coordinates of said space include a time coordinate, the control points having independently selectable time coordinate values:

- 30 - the image value computation circuit being arranged to compute pixel values of display images for a series of frame time values using the relative position of the locations in the matrix with respect to the control points, relative differences between a series of frame time values and time coordinate components of the control points being computed individually for each control point that is used.

30. A computer readable medium comprising a program of machine instructions to make a programmable computer perform the method of Claim 27.

- 5 31. A computer readable medium comprising a representation of a digital image that represents spatially filtered images that are obtainable from a common source image by application of spatial filter operations with respective filter bandwidths, wherein a dependence of image information in the filtered images on position in the filtered image and filter bandwidth is represented by information that defines a surface in a space that has at
- 10 least the position in the filtered image and the filter bandwidth as coordinates, the shape and position of the surface at least partly defining said dependence, wherein the medium stores coordinate information of control points that define an approximate version of said surface, the coordinate information being represented in way that allows the filter bandwidth coordinate component of each control point to be set independently of all the filter bandwidth
- 15 coordinate component of all other control points.